STAT

Page Denied

Sanitized Copy Approved for Release 2011/09/14 : CIA-RDP80-00809A000700190190-9

OSCILLATIONS IN GAS-DISCHARGE DEVICES

Elektrichestvo, No 2, pp 16-20
Moscow, Feb 1951

M. M. Chetverikova, Cand Tech Sci
Sci Res Inst of Phys,
Moscow State U
Submitted 9 Sep 1950

[The following report was delivered at the Section of Radio Methods of the All-Union Scientific and Technical Society of Radio Engineering and Electric Communications imeni A. S. Popov (VNORiE) on 20 March 1950, and also at the Scientific Council of the Scientific Research Institute of Physics and the Physics Faculty of Moscow State University imeni Lomonosov on 14 June 1950.

The abstract to the article stated the following: "The article presents basic results of the study of high-frequency oscillation generation by means both of gas-discharge devices specially developed for this purpose and of industrial thyratrons and gasotrons (gas-filled rectifiers). Oscillations were studied with generator circuits in which external oscillatory circuits were present and absent."

Table and figures referred to are appended.]

Oscillations in gas-discharge tubes with liquid pool-type or heater-type cathodes containing different gases at different pressures with different discharge and heater currents have been studied by many authors. These oscillations range in frequency from several tens of cycles per second to centimeter waves. It has been experimentally established that these oscillations cannot be explained only by the presence of oscillations in plasma. With the aid of gas-discharge tubes it is possible to excite oscillations of different types including, for example, oscillations analogous to those in the retarding field of an anode. Oscillations can be localized in both the anode and cathode regions of a discharge.

A large number of investigations by Soviet scientists has been devoted to "stenotrons," in which the effect of constricting the discharge is used to excite oscillations. Investigations were conducted at the All-Union Electrical Engineering Institute imeni Ul'yanov (Lenin) (VEI) by V. L. Granovskiy jointly with L. N. Bykhovskaya and G. L. Suyetin (1). Most of the research on oscillations in gas discharges has been conducted with the aid of special experimental tubes having little in common with gas-discharge devices of industrial types (gas-filled rectifiers, ignitrons, thyratrons, and powerful mercury-arc rectifiers). The problem of oscillations in gas-discharge devices has not received sufficient attention in the literature.

Oscillations in Thyratrons and Gas-Filled Rectifiers

Oscillations in thyratrons and gas-filled rectifiers were studied in the absence of an external oscillatory circuit on the apparatus whose schematic diagram appears in Figure 1. Since ac heating causes strong modulation of the oscillations being studied, dc was used for heating the filament. A 114-volt storage battery was used for anode power supply. In the investigation of oscillations in thyratrons the grid was grounded through resistance R_g 10^4 ohm, which was necessary for firing of the thyratron. After firing, the grid could be disconnected. The voltage drops on thyratrons and gas-filled rectifiers were measured with a high-resistance voltmeter; frequencies and amplitudes of the oscillations

STAT

were measured with a cathode-ray oscillograph EO-5, which was calibrated for different values of amplification and synchronization. The frequency F of the oscillations and the amplitude U_k of the ac voltage component were measured at the anode in dependence on the dc component of the anode current I_a, at heater current I_h = const or in dependence on I_h at I_a = const. The results of measurements of frequency F and amplitude of oscillations U_k from the filament current I_h are not cited here.

Below are presented some results of the study of oscillations in thyratrons TG-8/3000 and KU-635 and in the VG-237 gas-filled rectifiers. Evidently these oscillations originate mainly in the anode region, since oscillations at the grid of a thyratron are insignificant in amplitude and chaotic in form.

Observation of Oscillations in Thyratrons and Gas-Filled Rectifers

1. Systems Without External Oscillatory Circuits

Oscillations are observed in the TG-8/3000 thyratron for nearly all values of discharge current which are allowable for it from several milliamperes to 2 a (Figure 2). Starting with I_a = 1.7 a, the oscillations take on a disorderly character. Quantitative measurements at $I_a > 1.7$ a were not taken.

Oscillograms were taken for I_a = 250 ma, F = 102 kc and for I_a = 1.2 a, F = 75 kc at different amplifications and oscilloscope sweep rates.

In the KU-635 thyratron, however, oscillations arise intermittently at I_a = 0.3 a (Figure 3). The oscillation frequency changes from 24 to 50 kc when the discharge current is varied from 0.3 to 2.5 a. The amplitude of oscillations U_k is considerably higher than with the thyratron TG-8/3000. The characteristics shown by the solid and dotted lines are for two different specimens of the KU-635 thyratron. The small difference in frequency of oscillations is explained by the fact that the internal parameters of the thyratrons (electrode configurations and pressures) were not completely indentical.

The oscillations are of a stable character and their form, which is close to sinusoidal at the beginning, becomes distorted as the discharge current increases.

In the VG-237 gas-filled rectifier, oscillations were observed only for a very small range of variation of the discharge current (from 2 to 450 ma). Beginning with 14 ma, the oscillations become chaotic and their amplitude rapidly decreases (Figure 4). At I_a = 450 ma oscillations disappear. Clearly observable oscillations occur in the range from 2 to 13 ma. The oscillation frequency has a sharp minimum at I_a = 5 ma, while the amplitude has a sharp maximum at I_a = 6 - 7 ma. The form of the oscillations depends to a considerable extent on the value of the discharge current.

2. Isolation of Oscillations in an External Oscillatory Circuit

In order to isolate the high-frequency component, the oscillation generator was connected in parallel with an external oscillatory circuit (Figure 5). Operation of the generator was studied on two specimens of thyratron Ku-635 at I = 2 a. The resonance frequency for one specimen was f = 47 kc, for the other f = 39 kc. The greatest amplitude of voltage on the oscillatory circuit was 60 v. Tuning to resonance was accomplished by varying one of three values (I_a, I_h, or $C = C_1 + C_2$), while the other two were held constant. Rough tuning was accomplished by varying C_2 and I_a, and fine tuning was accomplished by varying C_1 and I_h (within the allowable limits). The power isolated in the oscillatory circuit was of the order of 1 watt.

Connecting the oscillatory circuit as a load for the high-frequency component of the thyratron anode current distorts the form of anode oscillations.

In view of the small internal resistance of a thyratron, series connection of the oscillatory circuit to the main circuit seemed most rational. The internal resistance of the thyratron in this case went into the oscillatory circuit. When R = 20 ohm (including the resistance of a thermal milliammeter), the current in the oscillatory circuit reached 330 ma and the power reached 2 watts. For excitation of high-power oscillations with gas-discharge devices of the usual type (thyratrons, mercury-arc rectifiers, ignitrons, etc.), development of special generator circuits is necessary.

__Generation of High-Frequency Oscillations by Means of Gas-Discharge Devices With Mercury Cathodes__

In working out the design of a gas-discharge device intended for the generation of high-power and high-frequency oscillations, the liquid pool cathode with a nonfixed cathode spot, which does not limit the current to be converted, is of basic interest. The gas-discharge device with a mercury cathode selected for experimental purpose was a type RMNV-500 uncontrolled demountable metal mercury-arc rectifier.

The results cited below were obtained by us in studying the RMNV-500 anode assembly. The deionization grid was removed from the anode sleeve and two electrodes, g_1 and g_2 (Figure 6), were placed at a given distance from the anode. The electrodes were connected to vacuum bushings built in to the flange of the anode assembly.

The oscillations were investigated with the excitation switched on. They were observed on a cathode-ray oscilloscope type EO-5 calibrated for different values of amplification and synchronization. In taking the load characteristic $U_{g2} = f(I_{g2})$, the frequency F and the oscillation amplitude U_k were measured as a function of the load current I_{g2}. Using the circuit in Figures 8, oscillations were obtained in the range from 4 to 112 kc. The amplitude of oscillations U_k was measured in the range from 6.35 to 58 v. Oscillations with frequency F = 4 kc and amplitude U_h = 17.4 v were obtained at C_2 = 25 μfd, C_4 = 1.5 μfd, C_5 = 0, and C_1 = 0.5 μfd; the dc component of the discharge current I_{g2} was 0.2 a.

Oscillations with a frequency F = 112 kc were obtained at C_1 = 1 μfd, C_2 = 22 μfd, C_4 = 1.5 μfd, and C_5 = 11,600 $\mu\mu$fd; the dc component of the discharge current I_{g2} was 4.5 a. Oscillations of the amplitude U = 58 v were obtained under the following conditions. C_1 = 0.5 μfd, C_2 = 25 μfd, C_4 = 1.5 μfd, C_5 = 0; the dc component of the discharge current I_{g2} was 10 a. The form of the oscillations F = 14.8 kc was recorded by the EO-5 cathode-ray oscilloscope. The dc component of the discharge current I_{g2} was 2 a; U_{g2} was 36 v.

In Figure 7 the curves 1 and 2 show the dependence of oscillation frequency and amplitude on capacitor C_2, while curves 3 and 4 and 5 and 6 show the dependence of the same parameters on the discharge current I_{g2}.

Neither varying C from 0.25 μfd to 2 μfd nor disconnecting C_1 and g_1 from the circuit has any affect on the frequency or amplitudes of the oscillations. In the circuit shown in Figure 6 the frequency and amplitude of the oscillations are determined by the external parameters of the circuit and the value of the discharge current. We studied oscillation phenomena in 11 different circuits. Oscillations with frequency F = 21.8 kc and U_k = 33 v for one of the variants of these circuits (Figure 8) were observed for I_{g2} = 2.5 a and C = 3 μfd.

The frequency and amplitude of oscillations for different capacitances C and discharge currents I_{g2} or I_{g1} for the circuit in Figure 8 are cited in Table 1. It is not difficult to see that in this circuit the discharge currents I_{g2} and I_{g1} have no effect on the frequency of oscillations. The amplitude of oscillations U_k, however, grows with an increase in I_{g2} or I_{g1}. It was also established that in the circuit of Figure 8 connection of capacitance and inductance in series between electrode g_1 and the cathode does not affect either the frequency or amplitude of the oscillations.

Conclusion

Further study as to the possibility of increasing the frequency and power of oscillations generated in gas-discharge devices is needed. It is also necessary to study oscillations in gas discharge devices as causes of breakdowns and sources of interference. The relation between backfirings and oscillations in gas-discharge devices should be cleared up. Superimposing the characteristics $F = f(I_a)$ on $U_k = f(I_a)$ of thyratrons PG-8/3000 and KU-635 with the values of their maximum allowable back voltages shows that an increase in oscillation amplitude (for thyratron KU-635) corresponds to a decrease in the allowable value of back voltage. This proposition should be checked with other types of gas-discharge devices.

Participating in the investigation of oscillations in gas-discharge devices were student V. I. Shelyunskiy (thyratrons and gas-filled rectifiers) and scientific associates P. P. Klimentov and P. M. Sviridov (mercury-cathode devices).

BIBLIOGRAPHY

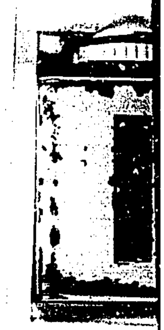
1. L. N. Bykhovskaya and V. L. Granovskiy, DAN SSSR, Vol XLIX, No 5, 1945, p 348, Zhur Eksp i Teor Fiz, Vol 16, No 9, 1946; V. L. Granovskiy and G. L. Suyetin, DAN SSSR, Vol XLIX, No 6, 1945, p 420; G. L. Suyetin, Zhur Tekh Fiz, Vol XVII, No 7, 1947, p 809.

[Table and figures follow.]

Table 1

I_{g2}, a	0.76	1.25	1.3	1.3	1.3	1.3	1.5
C, μfd	2	0.25	0.5	1	2	2.5	2.5
F, kc	16.2	49.5	34.2	23.2	16.2	15.2	14.4
U_k, v	30	9	9.75	8.25	16.6	13.5	17
I_{g2}, a	1.75	2.0	2.25	2.5	2.5	2.5	2.5
C, μfd	2.5	2.5	2.5	2.5	2	3	0.25
F, kc	12.8	13.5	15.0	14.2	16.6	21.8	43.8
U_k, v	20.3	26.3	25	22.5	35	33	18.6

Sanitized Copy Approved for Release 2011/09/14 : CIA-RDP80-00809A000700190190-9



I_{gl} = 1.53 a

C, μfd	0.25	0.5	0.75	1.0	1.25	1.5	1.75		
F, kc	52	36	25	23	22.2	19.5	18.8		
U_k v	0.5	0.8	0.7	1	1.05	1.0	1.05		
C, μfd	2.0	2.25	2.5	2.75	3.0	3.25	3.5	3.75	
F, kc	17.0	14.8	13.5	12.6	13.0	11.7	11.7	12.0	
U_k, v	0.9	0.8	0.8	1.1	1.35	1.5	1.45	1.2	
C, μfd	4.0	4.25	4.5	4.75	5.0	5.25	5.5	5.75	7
F, kc	10.4	10.4	10.4	10.4	10.4	9.8	9.8	9.0	8.0
U_k, v	1.1	1.05	1.05	1.05	1.1	1.1	1.1	1.1	1.1

I_{gl} = 5.1 a

C, μfd	0.25	0.5	0.75	1.0	3.0
F, kc	52	36	25	23	13
U_k, v	1.05	1.35	1.5	1.45	2.1

STAT

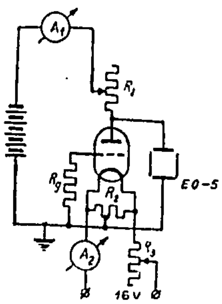


Figure 1.

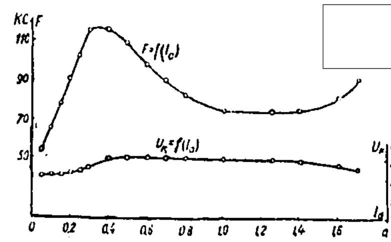


Figure 2.

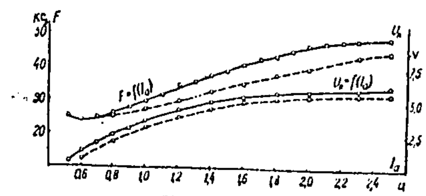


Figure 3.

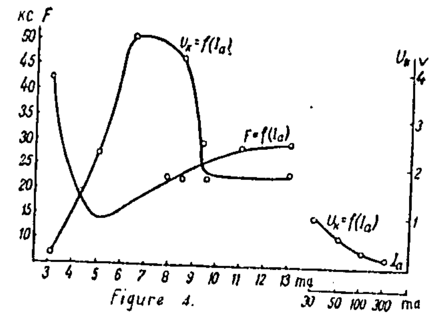


Figure 4.

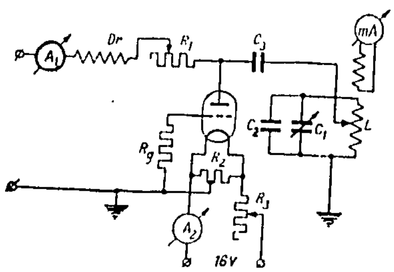


Figure 5.

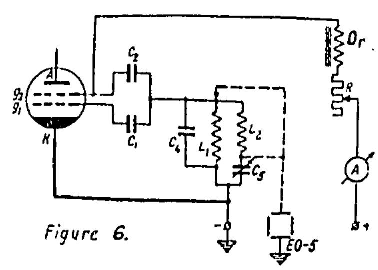


Figure 6.

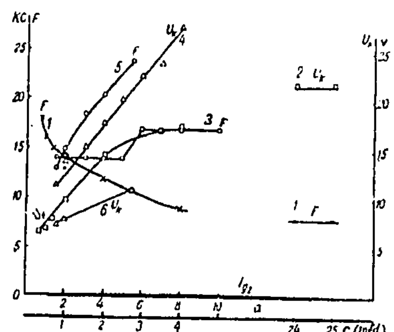


Figure 7.

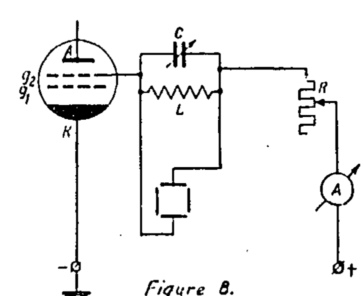


Figure 8.

STAT

- END -